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13. ABSTRACT (*Maximum 200 words*)

The littoral zone and inner continental shelf represent gateways through which continentally-derived sediment must pass on their journey to the sea. However, our knowledge of sedimentary processes and their spatial and temporal variability in these dynamic environments remains limited because of difficulties working in near shore environments and inadequate shallow water sonar technology. Improved geophysical imaging of the preserved stratigraphy in shallow water regions is critical to determining the transfer functions between high-frequency sedimentary processes and the formation of the longer-term stratigraphic record. To improve understanding of the sedimentary record preserved in the littoral zone and inner continental shelf, the Woods Hole Oceanographic Institution, together with Florida Atlantic University and Edgetech, have developed SUBSCAN, a state-of-the-art Chirp seismic reflection and side-scan system that images both the seafloor and subbottom sedimentary layers in shallow water environments. The subbottom Chirp system sweeps across a broad frequency band (0.5 - 16 kHz) and is digitally-recorded, which will allow us to examine different frequency bands across the same geologic features. Seismic systems operating at different frequencies reveal different reflection patterns, not only because higher-frequency systems have greater resolving capability, but also because reflections are often caused by complex interference patterns between closely-spaced stratigraphic horizons and outgoing signals. Understanding the frequency dependence of seismic reflectors is a critical first step toward determining the origin of seismic reflectors, quantifying reflection coefficients, and assessing the spatial variability of reflectors. The side-scan sonar is a dual frequency (100 & 500 kHz) Edgetech DF1000 system.

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Implementation and Design of a Shallow Water Imaging System

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Final Report for Project N00014-96-1-1069

Abstract

The littoral zone and inner continental shelf represent gateways through which continentally-derived sediment must pass on their journey to the sea. However, our knowledge of sedimentary processes and their spatial and temporal variability in these dynamic environments remains limited because of difficulties working in near shore environments and inadequate shallow water sonar technology. Improved geophysical imaging of the preserved stratigraphy in shallow water regions is critical to determining the transfer functions between high-frequency sedimentary processes and the formation of the longer-term stratigraphic record. To improve understanding of the sedimentary record preserved in the littoral zone and inner continental shelf, the Woods Hole Oceanographic Institution, together with Florida Atlantic University and Edgetech, have developed SUBSCAN, a state-of-the-art Chirp seismic reflection and side-scan system that images both the seafloor and subbottom sedimentary layers in shallow water environments. The subbottom Chirp system sweeps across a broad frequency band (0.5 - 16 kHz) and is digitally-recorded, which will allow us to examine different frequency bands across the same geologic features. Seismic systems operating at different frequencies reveal different reflection patterns, not only because higher-frequency systems have greater resolving capability, but also because reflections are often caused by complex interference patterns between closely-spaced stratigraphic horizons and outgoing signals. Understanding the frequency dependence of seismic reflectors is a critical first step toward determining the origin of seismic reflectors, quantifying reflection coefficients, and assessing the spatial variability of reflectors. The side-scan sonar is a dual frequency (100 & 500 kHz) Edgetech DF1000 system.

Long-Term Goals:

Our long-term goal is to develop and improve acoustic techniques for imaging fine-scale stratigraphy in shallow-water environments Improved resolution of the preserved stratigraphy in shallow water regions is the necessary first step to determining the transfer functions between high-frequency sedimentary processes and the formation of the longer-term stratigraphic record. The dynamics linking physical processes operative on small spatial and temporal scales ("event" stratigraphy) to the formation of the longer-term stratigraphic record must be understood in order

for us to construct realistic quantitative stratigraphic and morphologic models for shallow water regions.

Scientific Objectives:

Toward improved imaging capabilities of fine-scale stratigraphy, we have developed/modified a Chirp side-scan sonar system (SUBSCAN) that will allow us to collect high resolution seismic data in littoral environments (surf zone to mid-shelf water depths). We have collaborated with researchers at Florida Atlantic University (FAU, Steve Shock), who pioneered the development of CHIRP technology and spearheaded the development of the new acoustical techniques. The funds to design and implement the new SUBSCAN System were provided by both DURIP and ONR. The system will be portable, easily mobilized and available for use on research vessels of opportunity. Turn-key operations will enable researchers to acquire high-resolution seismic images across the littoral zone by providing advanced user-friendly software for automated data analysis.

Approach:

We conducted several equipment demonstrations onboard the R/V Asterias and onshore in 1996, 1997, and 1998 (Elics, Klein, Ocean Acoustics, Datasonics & EdgeTech) to determine the imaging capabilities of the existing systems and ascertain which system was best suited for our proposed modifications. Upon defining the best subbottom imaging system, we began modify the transducers and receiving arrays to improve the subbottom imagining capabilities of the system.

Accomplishments and Results:

- Based on the equipment demonstrations and subsurface resolving capabilities, we purchased an EdgeTech SUBSCAN SB-0512 with dual frequency side-scan sonar (100/500 kHz) and accompanying MIDAS acquisition and processing software.
- We conducted several additional expeditions onboard the R/V Asterias to further test the system and map subsurface channels in Vineyard and Nantucket Sounds. In addition, we have conducted additional shakedown cruises offshore New Jersey, Hudson River, NY, and Boston harbor. New Jersey and Boston harbor surveys were selected as survey areas because of the numerous well borings located in these regions that allowed us to groundtruth the CHIRP subbottom seismic data.
- We are collaborating with Steve Shock from Florida Atlantic University, who is modifying the tranducers and receiving arrays in the SB-0512 fish to improve the imaging capability of the system. A shakedown cruise conducted in the Chesapeake Bay during the summer (1997) revealed that the new transducer configuration improved both subbottom penetration and resolution.
- We have constructed a tow sled for the SB-0512 fish based on designs developed at Florida Atlantic University. Additional modifications to the SB-0512 acoustic shields have further reduced

trapped multiples off the fish as well as sea-surface multiples. The towing frame, winch, and deployment system are designed for small research vessels and operation in high energy environments. The tow frame has been designed to be stable on the bottom while being towed slowly across the surf zone out to greater water depths. Outside the surf zone the vehicle will be flown in a traditional configuration while maintaining a constant depth above the seafloor.

• We have a collaborative agreement with EdgeTech to cost-share software and hardware modifications required to accommodate the necessary modification to the SB-0512 fish and topside software.

• A differential GPS and hydrographic survey system have been linked to the MIDAS topside software to acquire positional data with approximately 5 meter accuracy and provide helm guidance during the running of pre-defined survey lines.

Scientific Impact:

Determining the transfer functions between short term processes "event stratigraphy", the formation of the longer-term stratigraphic record, and the occurrence of seismic reflectors requires a multidisciplinary coordinated effort that brings together many disparate data sets (e.g., geological, geophysical, hydrodynamic, climatic, and historical data). Seismic systems operating at different frequencies reveal different reflection patterns, not only because higher-frequency systems have greater resolving capability, but also because reflections are often caused by complex interference patterns between closely-spaced stratigraphic horizons and outgoing signals. Consequently, multiple surveys with overlapping ranges of frequencies across the entire continental margin from the shoreline to the deep sea are needed to determine the origin of seismic reflectors, quantify reflection coefficients, and assess the spatial variability of reflectors. In order to determine how sedimentary sequences and their bounding unconformities are formed, it is imperative that we image sequences at resolutions consistent with the processes we are investigating. The dynamics linking physical processes to the formation of the longer-term stratigraphic record must be understood in order for us to construct realistic quantitative stratigraphic and morphologic models for shallow water regions.

Transitions:

The new SUBSCAN System will be used as part of a STRATAFORM cruise off the Eel River in July of 1998 onboard the R/V Wecoma (Nittrouer). In addition, the new system will be used to map the morphology and fine-scale stratigraphy of the shallow water region (<65 m) surrounding the Eel River, California to define the spatial and temporal variability of the Eel River subaqueous delta and to determine its relationship to the surrounding shallow water regions and mid-shelf fine-grained flood deposits (August, 1998). Finally, the data acquired during the SB-0512 sea trials in

Vineyard, Nantucket Sound, and Hudson River are being used as part of a Ph.D. thesis (B. Gutierrez & J. Woodruf).

Related Projects:

The goals of this project interface with the objectives of a number of ongoing and proposed research projects within the ONR STRATAFORM Initiative both on the east and west coast of the United States. Furthermore, understanding the processes that transfer sediment, sculpt the continental margin, and create stratigraphic sequences can lead to predictive quantitative models of bottom morphology, acoustic character, stratal architecture, and facies distribution that can be applied to other littoral zones throughout the world.

Subscan System Components:

The SUBSCAN System is a state of the art seismic and side scan imaging system funded by ONR. The Chirp and side scan systems can be used separately or the two can be mounted on the sled as a unit and towed along the sea floor. When the system is flown in a more traditional configuration, the two systems should be physically separated because the side-scan fish will be towed at a different height above the bottom than the sub-bottom Chirp fish.

The system includes;

1) a DF1000 towfish and topside unit
2) a X-Star subbottom sonar including:
    a) a SB0512 tow fish with
        i) 2 planar receiving arrays
        ii) Woofer/tweeter transmitting pair covering the range of 0.5 -16 kHz
        iii) 31" pressure housing containing matching transformers, 2 channel power amp, 2 channel receiving amp, matching transformers, 2 channel DGA and A/D converters and associated DSP processors, Pentium 2 computer, ADSL telemetry transceiver, 300 VDC to 48/12/5 VDC power supplies
        iv) Pitch/Roll sensor
    b) A shipboard interface unit (SIU) that provides 300 VDC power to fish and the ADSL telemetry transceiver, hardware and software diagnostics, and an Ethernet output. There is a Pentium host.
    c) A topside Pentium processor with an ethernet input from the SIU. This performs the following
        i) Subbottom image display during acquisition and playback
        ii) Navigation interface

iii) Seg-Y storage of subbottom and navigation data

The system also includes a tow winch with 500 meters of cable with remote controls, which allows the fish to be flown in real time. The complete system is shipped in its own 20 foot van.

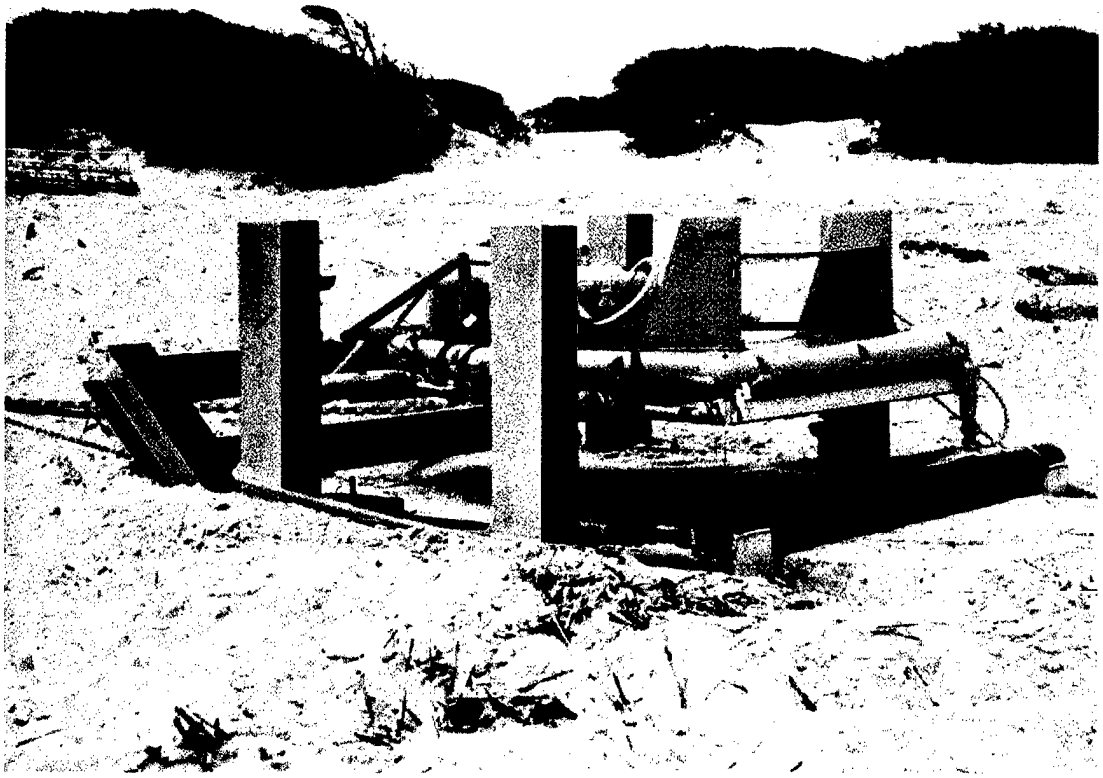
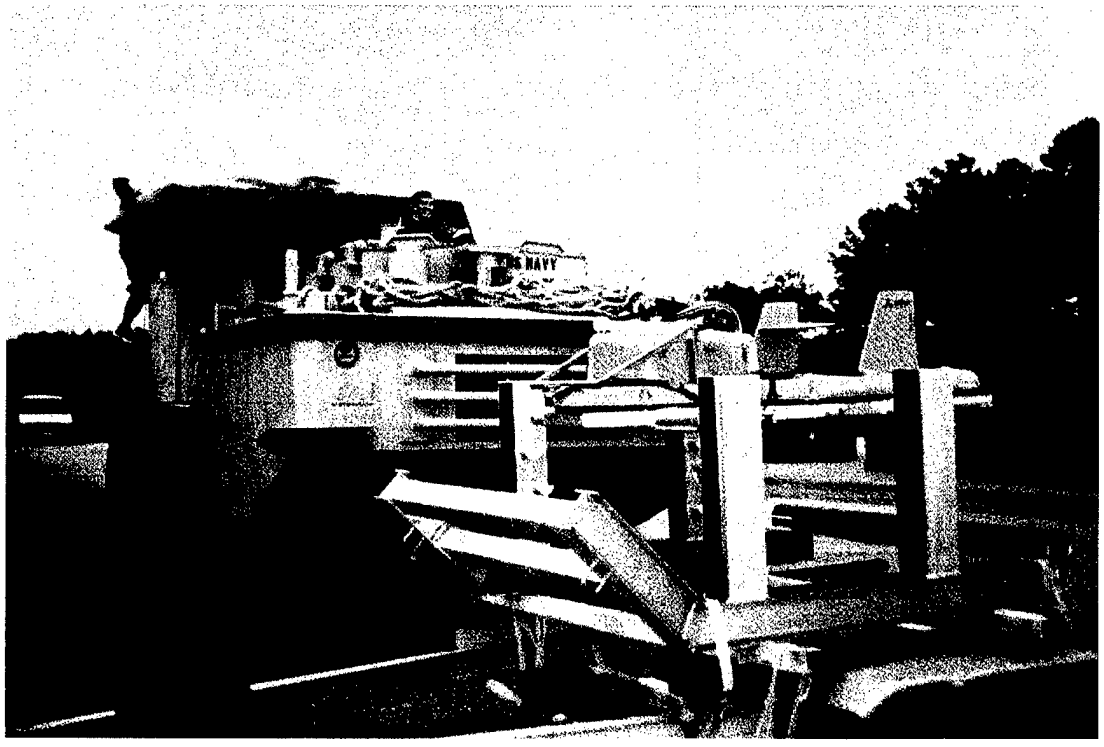


Figure 1. Color photos showing an Edgetech 0512 system with modified transducers. The transducers are mounted near the front of the fish in the large tear drop with the receiving arrays being located near the rear of the vehicle with their long axis parallel the fish. Dependent on the substrate and shallow water morphology the fish can be raised or lowered in the towing frame. Match filtering and D/A conversion will performed on the fish and telemetered up the Rochester 501 cable to the Topside computers.



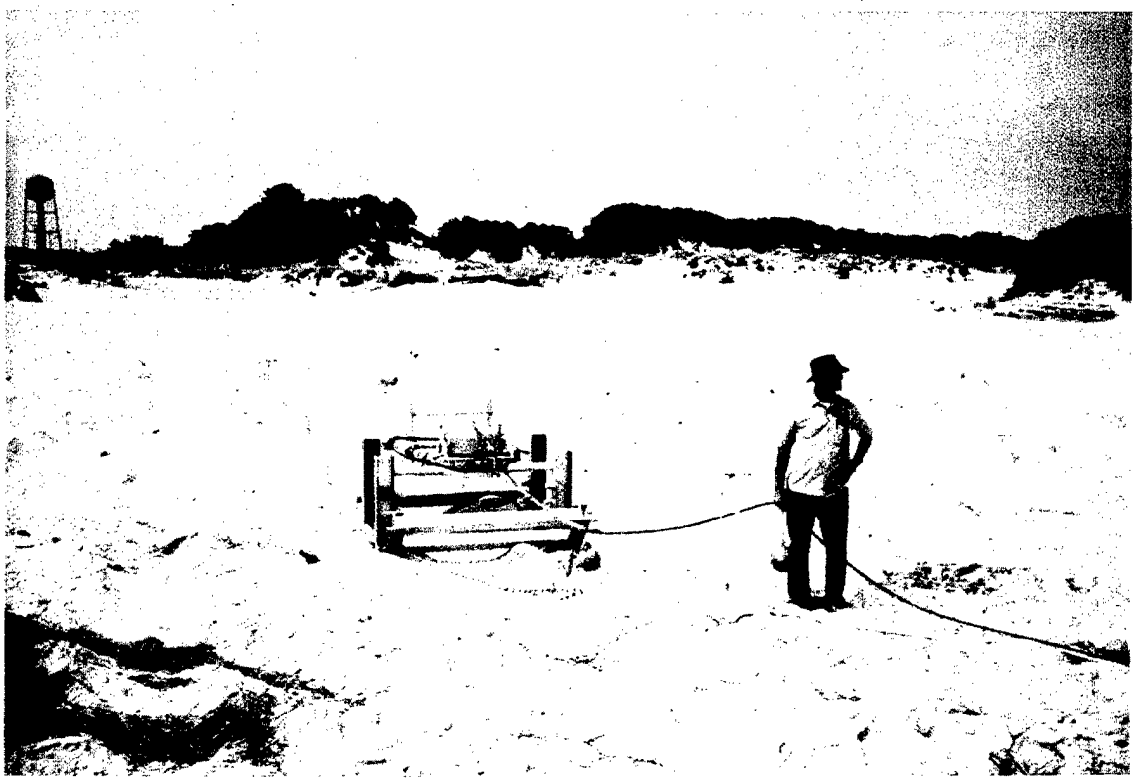
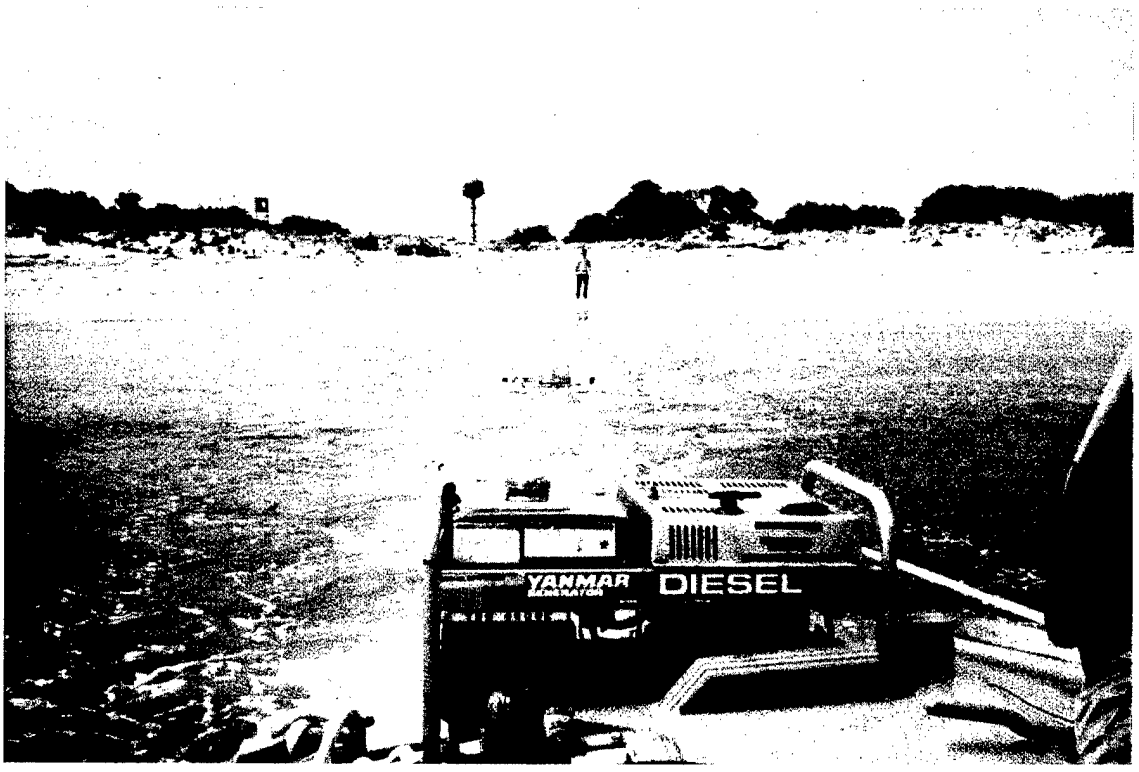


Figure 2. SUBSCAN system with tow sled being deployed from the beach. The towing frame, winch, and deployment system are designed for small research vessels and operation in high energy environments. The tow frame has been designed to be stable on the bottom while being towed slowly across the surf zone out to greater water depths. Outside the surf zone the vehicle will be flown in a traditional configuration while maintaining a constant depth above the seafloor..



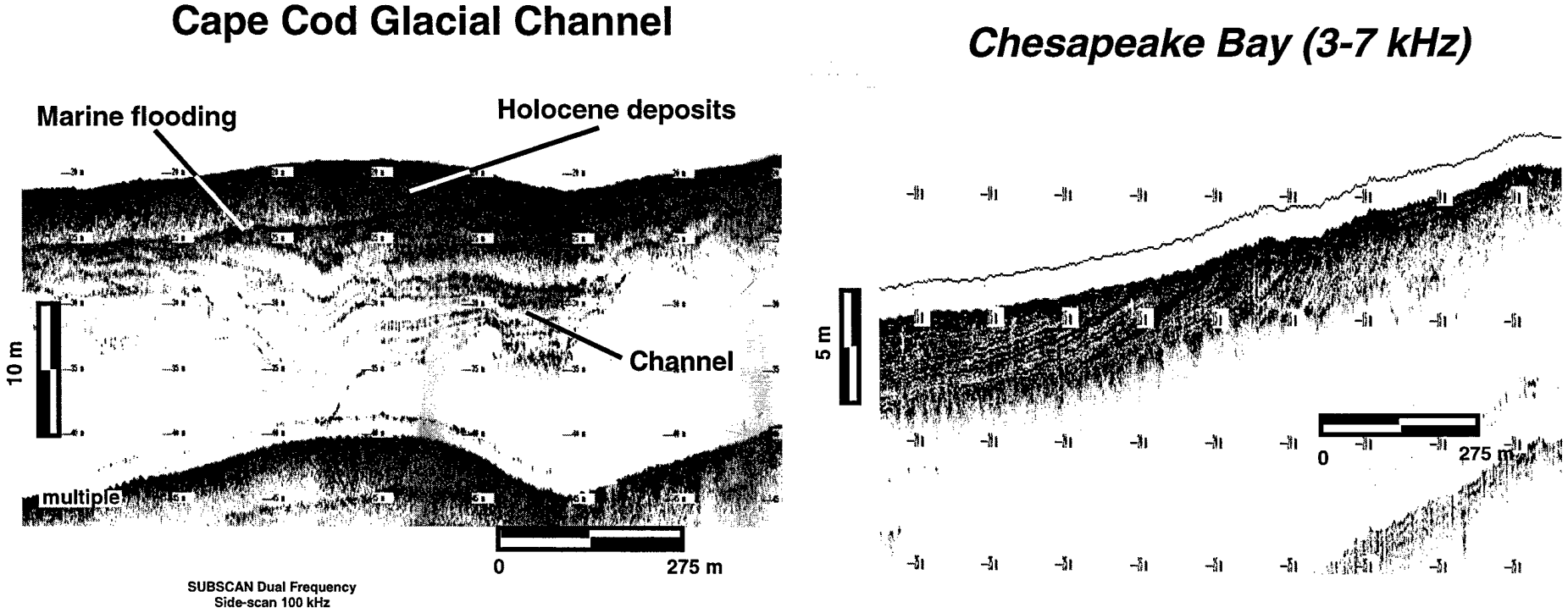


Figure 3. (*Upper left*) Using a prototype of our new SUBSCAN system, high resolution sonar data were collected across the seaward extent of the linear Cape Cod valleys which for the first time clearly imaged the internal structure of the channel fill and overlying stratigraphy. The system was able to penetrate ~20 m beneath the Holocene to Present sands and gravels. (*Upper right*) Given the broad band capabilities of the system, two separate swept frequencies (e.g., .5 - 7 kHz and 2 -16 kHz) can be examined concomitantly that will allow us to collect deep penetration as well as high resolution data. An example of high resolution data from the Chesapeake Bay is shown. (*Lower left*) 100 kHz sidescan record that will be collected with the subbottom data. (*Lower right*) 500 kHz sidescan data that will also be collected and will permit examination of backscatter variation with frequency.

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June 30, 1997

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Dear Sir:

In compliance with the reporting requirements of ONR Grant No. N00014-94-1-0466 entitled "Implementation and Design of a Shallow Water Imaging System", PIs Neal W. Driscoll, Wayne D. Spencer and David G. Aubrey, enclosed are two copies for your files.

Sincerely yours,

Neal W. Driscoll

NWD:pf

Enclosure